with plan defined as "any hierarchical process in the organism that can control the order in which a sequence of operations is to be performed" (Miller et al., 1960, p. 16, italics theirs).

The two scenarios discussed above illustrate what is meant by "teacher as decision maker" in this paper (cf. Coladarci, 1959; McDonald, 1965; Packer & Packer, 1959; Strasser, 1967). They also show the critical connection between teaching skills and the basic teaching skill: decision making.

Methods for Research on Teachers' Decisions

The various conceptualizations of the teacher as decision maker have not led to empirical verifications (Coladarci, 1959; McDonald, 1965; Strasser, 1967). The purpose of this section is to review methodology for examining teachers' extemporaneous decisions (e.g., Stolurow, 1965; Turner, 1971). Perhaps this tack will stimulate research on teachers' decision-making processes.

Examining Decisions from Descriptions of Teacher-Student Interaction

To examine teachers' decisions from descriptions of teacher-student interaction, basic teaching skills ("alternative acts") are identified (cf. Smith et al., 1962), or sequences of basic skills described (cf. Figures 2-4; Bellack et al., 1966; Taba & Elzey, 1964; Taba, Levine, & Elzey, 1964; Smith et al., 1966).

Alternative basic teaching skills available to teacher (cf. alternatives in a decision matrix) can be described in a number of different ways. One is the logical approach, exemplified by Smith et al. (1962).

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THE BASIC TEACHING SKILL: DECISION MAKING

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Introductory Statement

The Center's mission is to improve teaching in American schools. Too many teachers still employ a didactic style aimed at filling passive students with facts. The teacher's environment often prevents him from changing his style, and may indeed drive him out of the profession. And the children of the poor typically suffer from the worst teaching.

The Center uses the resources of the behavioral sciences in pursuing its objectives. Drawing primarily upon psychology and sociology, but also upon other behavioral science disciplines, the Center has formulated programs of research, development, demonstration, and dissemination in three areas. Program 1, Teaching Effectiveness, is now developing a Model Teacher Training System that can be used to train both beginning and experienced teachers in effective teaching skills. Program 2, The Environment for Teaching, is developing models of school organization and ways of evaluating teachers that will encourage teachers to become more professional and more committed. Program 3, Teaching Students from Low-Income Areas, is developing materials and procedures for motivating both students and teachers in low-income schools.

This memorandum reports research conducted by the Assessment System component of the Program on Teaching Effectiveness. One problem for the Assessment System is to refine measurement techniques linking teaching acts to student achievement and attitude. In this paper, the teacher is conceptualized as a decision maker, and a teaching act is viewed as the result of a decision to use one or another teaching skill. To examine only the frequency with which the skill is employed is to ignore important information about when the teacher chooses to use it. It may be that information about this latter decision accounts for student outcomes better than frequency-of-use information, or at least in conjunction with it. Various methods of examining a teacher's decisions are reviewed.

Abstract

Any teaching act is the result of a decision, either conscious or unconscious. Previous research on basic teaching skills examined alternative teaching acts (e.g., explaining, questioning, reinforcing) without examining how teachers choose between one or another act at a given point in time. This paper argues that the basic teaching skill is decision making. What distinguishes the exceptional teacher from his or her colleagues is not the ability to ask, say, a higher-order question, but the ability to decide when to ask such a question. This decision-making process is examined using decision theory. Viewed from the decision theory perspective, a teacher has a number of alternative acts from which to choose. The choice may depend, for example, upon the teacher's subjective estimation of a student's understanding of some material and the usefulness of various alternatives in increasing that understanding. Research on teaching skills is reviewed from this perspective to show how current methodology can be applied to the study of teachers' decision making. This conceptualization of the teacher as a decision maker incorporates previous research on basic teaching skills. Skills such as questioning and explaining represent the teacher's repertoire of alternative acts from which to choose, while skills such as listening and hypothesis generation influence the quality of information from which the teacher estimates the student's understanding and the utility of alternative acts. One implication is that teacher training should include a decision-making component that integrates the other basic skills.

THE BASIC TEACHING SKILL: DECISION MAKING

Richard J. Shavelson

Teachers make a great many decisions in the course of a day's teaching. In fact any teaching act is the result of a decision--sometimes conscious but more often not--that the teacher makes after the complex cognitive processing of available information.

Basic Teaching Skills and Decision Making

This reasoning is clarified by Snow's (1968) model of teacher-student interaction, shown in Figure 1. (Some other model, such as Strasser's [1967], might work as well.)

> The diagram identifies cognitive events that are presumably involved in heuristic teaching behavior. One can assume, for example, that at some given instant in an ongoing group discussion a teacher attends to significant cues regarding the course of discussion, makes inferences about that state of confusion in some problem faced by the students, decides on a kind of question or comment designed to open up a new aspect of the problem, and skillfully inserts the question or comment into the stream of discussion. It can be further suggested that both the current course of classroom events and the teacher's earlier acquisition of skills will have been influenced by the teacher's aptitudes for teaching (and for learning to teach), by his substantive knowledge and repertoire of technical and personal skills, and by his affective or temperamental state at any given moment (Snow, 1968, pp. 78-79; see also Snow, 1972).

The conceptualization of and research on basic teaching skills (e.g., McDonald & Allen, 1967; Rosenshine, 1970; Rosenshine & Furst, 1971), then, have focused on the "exercise of skilled performance" almost to the exclu-

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Parts of this paper were presented at the Symposium on Basic Teaching Skills in Chicago, April 8, 1972. A version of it will appear in the Journal of Teacher Education (in press).

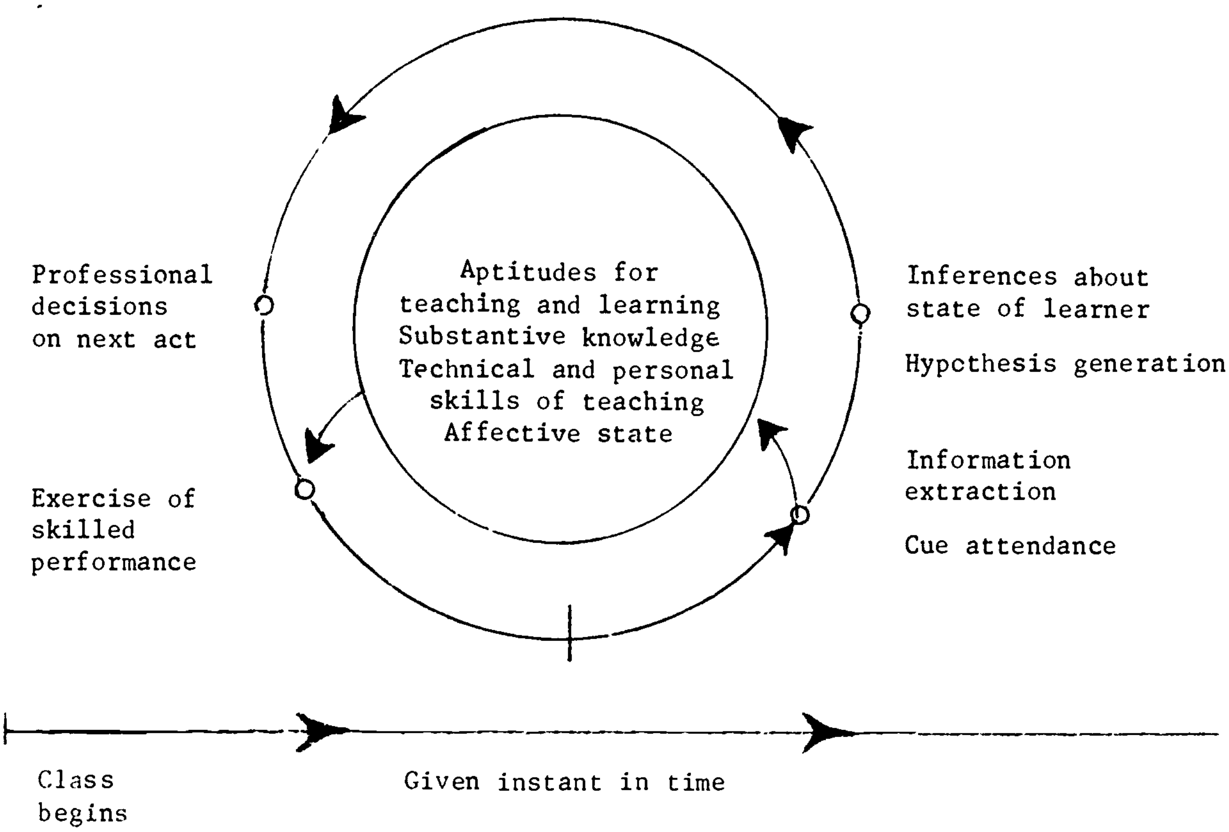

Fig. 1. Temporal course of teacher-learner interaction (based on Snow, 1968).

sion of other cognitive components of teaching behavior (some exceptions are Lundgren, 1972; Lundgren & Shavelson, 1972; Salomon & Sieber, 1970).

The connection between the current conceptualization of basic teaching skills and teacher decisions is illustrated by two scenarios. The first is as follows. As part of the research program at the Stanford Center for Research and Development in Teaching in 1967, interns (teacher trainees) in the Stanford Secondary Teacher Education Program were trained in a micro-teaching laboratory to use various "technical skills of teaching" (e.g., questions, reinforcement, probing, silence). Subsequently, the interns were videotaped in their classrooms. These videotapes are particularly instructive. In one tape, an intern begins a discussion with a question. Several

students respond by raising their hands. The intern calls on one student; he answers. Apparently dissatisfied with the answer, the intern asks this student a second question. The student does not respond. The student is asked a third question; apparently panicked, he mumbles something. Eventually the intern gives up on the student and redirects his questions to other students. If one were to count the frequency with which the intern used the technical skills of questioning and probing, he would receive a high score. If one could ascertain what the student learned, it probably would show little relation to the intern's "intent" or "plan." The critical factor was the intern's decision or decisions to continue questioning the student instead of using some other basic skills such as "explaining" or "refocusing."

This situation might be described as "individual decision making under uncertainty" (cf. Luce & Raiffa, 1967; Raiffa, 1969) and can be treated formally with concepts from decision theory. Our purpose is heuristic; decision theory presents a frame of reference for viewing a teacher's decisions.

Suppose the intern has a set of alternative basic teaching skills (e.g., questioning, explaining, refocusing) from which to choose his next teaching act. This set of skills (alternatives) can be represented symbolically $A_1, A_2, \ldots, A_i, \ldots, A_m$. Suppose further that the intern's preference for one skill instead of another depends on the student's present learning state (called "state of nature"). The student's state of nature might be "learned," "may have learned," or "unlearned" with reference to some subject matter. The student's learning state may be represented symbolically as s_1, s_2, s_3. Corresponding to each learning

state is the probability that the learner is actually in a particular state. This probability is assigned by the intern; it is subjective. The intern's choice, then, can be represented by an m x n matrix (Table 1)

TABLE 1

Teacher's Decision Matrix

STUDENT LEARNING STATES

ALTERNATIVE BASIC SKILLS	S_1**	S_2	S_3
	$Pr(S_1)$***	$Pr(S_2)$	$Pr(S_3)$
A_1*	u_{11}	u_{12}	u_{13}
A_2	u_{21}	u_{22}	u_{23}
A_3	u_{31}	u_{32}	u_{33}
.	.	.	.
.	.	.	.
.	.	.	.
A_i	.	.	.
.	.	.	.
.	.	.	.
A_m	u_{m1}	u_{m2}	u_{m3}

*A refers to the alternative teaching act (basic skill) available to the teacher (intern).

**S refers to a particular learning state of the student; i.e., "unlearned," "may be learned," or "learned."

***Pr(S) refers to the probability that a particular student is in that learning state. The probability is estimated subjectively by the teacher (intern).

with m rows (basic skills) and n columns (student states). For every cell in the matrix, there is an outcome. And, if the intern rank-orders every cell according to some preferred outcome, u_{ij} (assuming consistency; see Luce & Raiffa, 1967, Chapter 2), the intern should choose the row (skill) that is optimal in some sense. One strategy is the following. Any alternative basic skill (A_1) can be represented as the sum: $u_{i1}Pr(s_1) + u_{i2}Pr(s_2) + u_{i3}Pr(s_3)$. According to decision theory, the intern should choose the basic teaching skill with the largest row sum.[1]

The second scenario illustrating the relationship between basic teaching skills and decision making focuses on the sequential nature of decision making. It is drawn from the work of Taba and Elzey (1964). Using their observation system, student-teacher interaction can be represented by the flow chart in Figure 2.

> When the teacher attempts to raise the level of thought very early in the discussion, this typically results in the children's returning to a lower level and in their inability to sustain discussions at the higher levels of thought [at this point in the decision tree, the teacher inappropriately assigns a high utility (u) value to the cell which cont s the lifting question and/or a high probability value (Pr) to the "learned" state of the student]. On the other hand, a strategy representing an effective pacing of shifting the thought onto higher levels seems to follow a characteristic course [at each choice point on the decision tree, assign the following u and Pr values]. The level of seeking information is sustained for a considerable time during the first portion of discussion [assign high u values to such basic skills as lower-order questions, probing, explaining]. Grouping [e.g., forming categories for instances of a concept] is requested after a large amount of information has been accumulated [now assign a high u value to a

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1 This type of analysis can be extended to a sequence of decisions. The intern's decision to use a particular skill is represented as a node on a decision tree. The decision tree, then, represents the sequence of choices made by the intern.

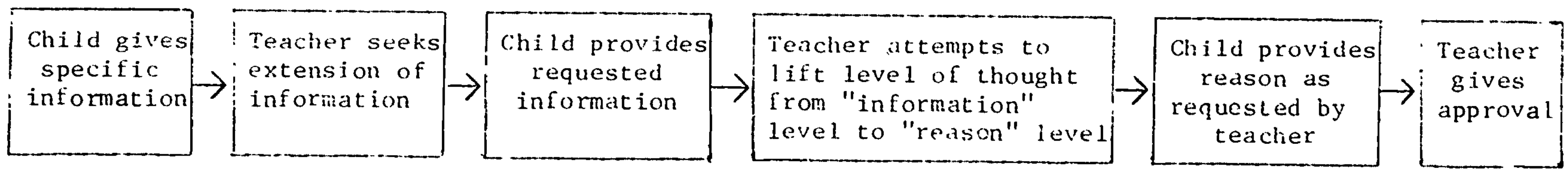

Fig. 2. Flow chart of teacher-child interaction, illustrating the sequential nature of decision making (based on Taba & Elzey, 1964).

> higher-order question]. The result is that in a fairly brief period, children transcend to labeling and then to providing reasons for labeling and to inferences (Taba & Elzey, 1964, pp. 532-33).

This sequence of decisions made by the teacher can be characterized by the TOTE unit (Miller, Galanter, & Pribram, 1960). TOTE stands for a Test-Operate-Test-Exit sequence, illustrated in Figure 3. The arrows in Figure 3 represent the transfer of control from one component of the TOTE unit to the next. The TOTE unit can be applied to Taba and Elzey's description as follows (illustrated in Figure 4). The teacher begins by testing (T) whether the student has sufficient information available to group instances of a concept; e.g., information available versus information needed. If the test result is incongruity, i.e., the information available is less than the information needed, the teacher moves to the

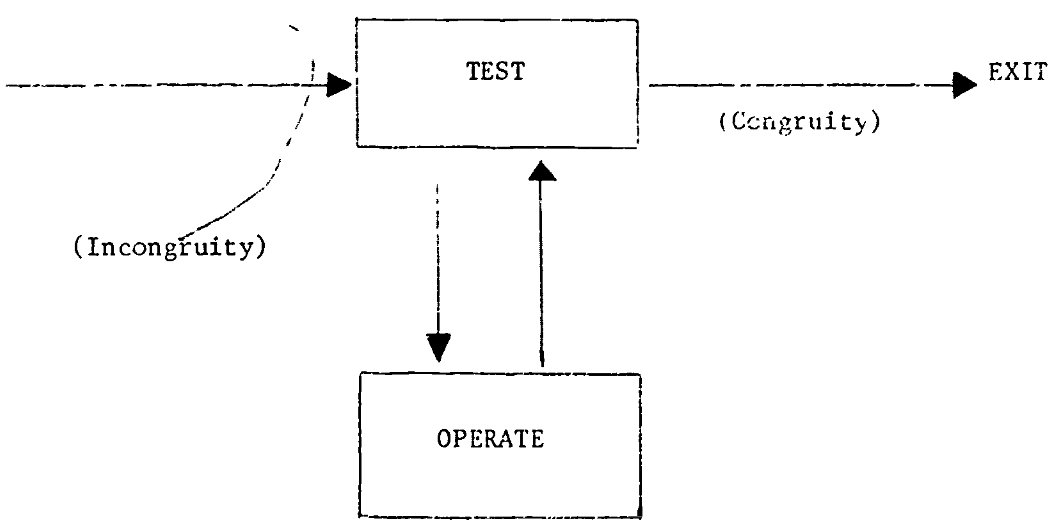

Fig. 3. The TOTE unit (after Miller, Galanter, & Pribram, 1960, p. 26).

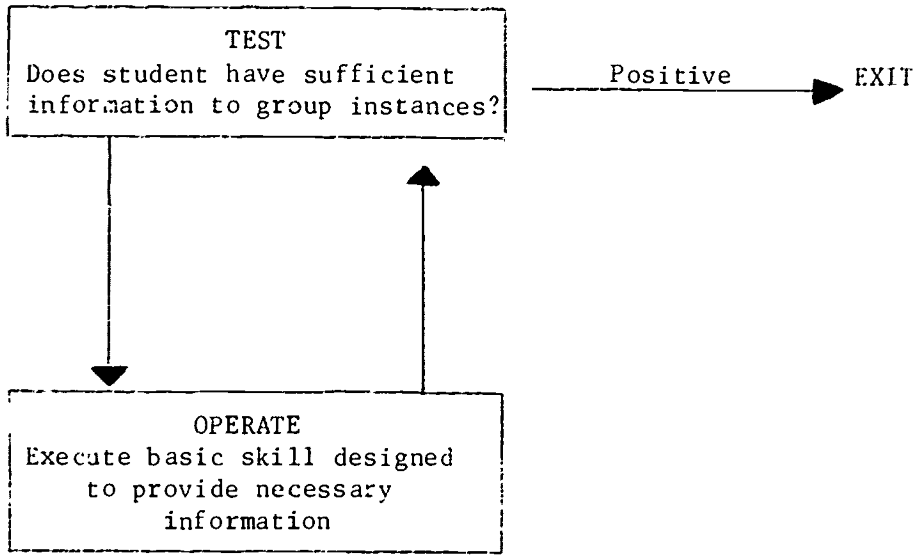

Fig. 4. Description of a sequence of decisions using the TOTE unit.

operate (O) component. Here the *u* values assigned to his decision matrix remain the same, he readjusts the subjective probabilities with respect to the student's learning state, determines the optimal basic skill, and then exercises that skill.[2] Again, the teacher tests (T) whether the student has sufficient information. If the test result is congruity, i.e., the information available equals or exceeds the information needed, the teacher *exits* (E) this phase, and moves to the next. The progress from phase to phase can be characterized as the teacher's plan (cf. the decision tree or Taba and Elzey's [1964] plan in the scenario above),

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[2] At least four operations are carried out at the (O) component. A better representation of this component is a hierarchy of TOTE units (see Miller et al., 1960, pp. 31-39). The hierarchy, however, introduces complexities beyond what is useful for the present discussion.

with plan defined as "any hierarchical process in the organism that can control the order in which a sequence of operations is to be performed" (Miller et al., 1960, p. 16, italics theirs).

The two scenarios discussed above illustrate what is meant by "teacher as decision maker" in this paper (cf. Coladarci, 1959; McDonald, 1965; Packer & Packer, 1959; Strasser, 1967). They also show the critical connection between teaching skills and the basic teaching skill: decision making.

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The various conceptualizations of the teacher as decision maker have not led to empirical verifications (Coladarci, 1959; McDonald, 1965; Strasser, 1967). The purpose of this section is to review methodology for examining teachers' extemporaneous decisions (e.g., Stolurow, 1965; Turner, 1971). Perhaps this tack will stimulate research on teachers' decision-making processes.

Examining Decisions from Descriptions of Teacher-Student Interaction

To examine teachers' decisions from descriptions of teacher-student interaction, basic teaching skills ("alternative acts") are identified (cf. Smith et al., 1962), or sequences of basic skills described (cf. Figures 2-4; Bellack et al., 1966; Taba & Elzey, 1964; Taba, Levine, & Elzey, 1964; Smith et al., 1966).

Alternative basic teaching skills available to teacher (cf. alternatives in a decision matrix) can be described in a number of different ways. One is the logical approach, exemplified by Smith et al. (1962).

Their unit of analysis--the episode--begins with and is classified by an expression or "entry" that triggers a verbal interchange about a topic, and ends with the conclusion of discussion on the topic. The classification of an entry--e.g., "defining" (a statement about how words or other symbols are used to refer to objects)--depends on the response that it logically demands as contrasted with the response that is actually given. "Such a response is a schema. It is a form to which responses to the members of a given class of entries would conform . . . were the responses logically correct" (pp. 34-35). These responses, then, might represent a list of alternative acts available to a teacher. The decision problem is how to choose one response from all logically possible responses.

A second approach is flow charting, as exemplified by the work of Taba and Elzey (1964; also Taba, Levine, & Elzey, 1964). The relation of this approach to teachers' decisions has already been discussed. One important application of this technique is being investigated by Moore (personal communication, 1972; 1973). She has constructed a game in which a player (teacher) teaches a "student." At present, the game simulates four types of students (man more types can be constructed to test various hypotheses): (a) high intelligence--high subject matter knowledge, (b) high intelligence--low subject matter knowledge, (c) low intelligence--high subject matter knowledge, and (d) low intelligence--low subject matter knowledge. These types are defined operationally by the student's position in the hierarchical structure of the learning task (subject matter knowledge) and by his ability to move upward in the

hierarchy (intelligence). The player is given 84 moves with which to teach the student. The moves, at present, are restricted to questions (higher- and lower-order) and explanations. To begin the game, the player arranges his moves into a plan, as defined earlier. Once the plan is established, the player interacts with one of the four students selected at random. The interaction involves a player's move and a student's binary response of "Yes, I can answer the question correctly," or "No, I cannot answer the question correctly." In general, any teacher move that deals with information below the student's position in the hierarchy receives a "Yes" response. A teacher move at the same level as the student in the hierarchy or higher may get a "Yes" response, depending on the teacher's past moves and the student's intelligence and subject matter knowledge. The game continues until the student has learned the terminal objective.

Moore's game can be described in decision theory terms. The moves are the alternatives from which the player must choose his next acts. The student's states are learned or unlearned.[3] For each move, the player's decision can be analyzed as in Table 1. And a flow chart (or decision tree) can be built that shows the sequence of decisions made by the player.

A third approach is sequential analysis of teacher or teacher-student acts. The interaction data are examined for stable patterns of acts (see, for example, Bellack et al., 1966). In some cases, these

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[3] Actually, the student can be in one of three states: learned, transition from unlearned to learned, or unlearned. This is consistent with current all-or-none mathematical models of learning (for a review, see Kintsch, 1970).

patterns tell about the teachers' (a) alternative basic teaching skills (acts), (b) judgments about the various learning states of the student or students (probabilities), and (c) preferences for various teaching act/student state outcomes (utilities).

The application of sequential analysis to the investigation of teachers' decisions is illustrated by S. Nicholson (personal communication). He used a statistical technique developed from information theory (cf. Attneave, 1959) to analyze sequences of higher- and lower-order questions. Preliminary results indicate a consistent pattern of questions for most teachers at the beginning of a lesson. Initially, the teacher asks lower-order questions. Then, a transition is made to higher-order questions (cf. Taba & Elzey, 1964). The stage at which this transition is made varies from one teacher to another.

If these results were cast into a decision framework, one possible result would be Table 2. Two alternative acts are available to the teacher of which he must choose one, and students are characterized simply as being in a learned or unlearned state. Since Nicholson's results apply to the initiation of instruction, assume that the probability of the students being in the unlearned state is 1.00. (Variability between patterns of teacher questions might derive from differances in probabilities assigned to learning states.) Finally, rank-order the various outcomes (cells) in Table 2 according to their desirability (utility). The rankings indicate that outcomes in the learned state are preferred to outcomes in the unlearned state, etc. (Variability between patterns of teacher questions also might be due to differences in priorities.) To choose one of the two types of questions,

TABLE 2

Hypothetical Decision Matrix for Nicholson's Data on Sequences of Teachers' Questioning: Beginning of Teacher-Student Interactions

	Student's Learning State		
Alternative basic skills	Unlearned	Learned	Row Sum
Lower-order question	2	3	2.00
Higher-order questions	1	4	1.00
Probabilities associated with student states	1.00	0.00	

determine the expected utility of each: $u_{11}p_1+u_{12}p_2$ (where _u_ is the ranking and _p_ is the probability estimate of the student's learning state). Table 2 shows that the expected utility (row sum) of lower-order questions is greater than for higher-order questions; the teacher therefore would be expected to choose a lower-order question.

At present, Nicholson has been unable to identify stable patterns of questions for an individual teacher beyond the initial stage of instruction. This finding points to the complexity of the sequence of decisions made by a teacher as instruction progresses. The absence of stable patterns might be due, in part, to the teacher's (a) use of other basic skills not represented in Nicholson's analysis of the interaction data, (b) identification of many different student learning states as instruction progresses, (c) inaccuracy in estimating student learning states, (d) inconsistency in assigning priorities to outcomes.

In conclusion, the various interpretations of Nicholson's work are almost entirely speculative. It has been discussed here to show how a sequential analysis of teacher acts for stable patterns might lead to important hypotheses about teachers' decisions.

One problem with sequential analysis is that the inference from the data to the teacher's decisions is often difficult to justify. The last approach to be discussed here, stimulated recall (Bloom, 1953; Jackson, 1968), offers a solution to this problem when combined with sequential analysis. With this method a recording is made of classroom interaction. It is played back to the teacher and is stopped at critical points in the interaction. The teacher is asked to report, say, alternative possible acts, judgments about the students' learning states, and the desirability of various outcomes. No study using this method of examining teachers' decisions has been found.

Examining Decisions on the Basis of Teaching Strategies

Teachers' decisions can be examined in the light of teaching strategies essentially in two ways. The first is post-hoc grouping. Student achievement or teacher-student interaction data are used to group teachers; differences between groups are examined. This form can be used in several ways to investigate teachers' decisions. One way is to compare groups of teachers on the basis of particular skills or combinations of skills that they use. Then the correspondence between the teacher's choice of skill and student achievement can be examined. For example, Bellack et al. (1966) grouped teachers according to whether their students had significantly higher-than-predicted or lower-than-predicted

mean scores on a posttest on international trade. After the teachers were grouped, a search was made for systematic differences in the two groups' pedagogical moves and teaching cycles. No consistent differences were found. A variant of this approach is discriminant analysis. With this technique, a linear combination of skills, skill sequences, or other variables is used to classify teachers into their original post-hoc groups. Once made, the classification into the original groups would yield important information on similarities and differences in decision making between groups.

The second way of examining teachers' decisions in the light of teaching strategies is <u>a priori</u> grouping. In this type of experiment, teachers are assigned randomly to a sequence of decisions. Studies in which teachers are assigned to one or another teaching method may be classified here. But the problem with this type of study is that teachers vary so much within groups that inter-group comparisons are difficult to interpret (see Dubin & Taveggia [1968] for a review of some of these studies).

Methods that Simulate Teachers' Decisions

The rationale for studying machine simulations or models of a master teacher, rather than the master teacher himself, is given by Stolurow (1965, p. 225): "The idea of modeling the master teacher has not worked. . . . Since there probably are fewer ways to teach effectively than to teach ineffectively, it is more likely that ineffective teaching behaviors would be identified in observational studies of teaching behavior."

Stolurow studies teaching through computer simulation. (One of his models is called SOCRATES: System for Organizing Content to Review and Teach Educational Subjects.) His method is descriptive in the sense that it makes "explicit the elements and relationships needed to account for the phenomenon in which we are interested (e.g., a student's performance on a learning task)" (p. 229). It is not descriptive of the human teacher; the human teacher may operate in different ways to achieve the same goal as the machine. Nevertheless, the programs (algorithms) used in the machine simulation suggest the types of decisions that need or ought to be made during extemporaneous instruction (cf. Stolurow's [1965] tutorial process).

The objectives for the Tutorial phase of SOCRATES are to implement the program (cf. the Operation phase of the TOTE unit, which might be a hierarchy of other TOTE units) and to monitor the student's progress (cf. the Test phase of the TOTE unit). The program contains two components: the units of subject matter to be learned, and the decision rules applied to the student's performance. The decision rules perform the following functions among others: (a) "specify the performance that is sufficient to provide knowledge or results" (p. 232); (b) "specify that the response must be correct before the student is allowed to go on to the next item or concept" (p. 233, cf. Taba & Elzey's [1964] information-gathering stage, or the Test of a TOTE unit); (c) specify that, at some minimum (unacceptable) level of performance, the program is to be changed (or the student is to be given more practice). "Each rule that specifies a contingency is an aspect of the complex process called

teaching; a complete set of rules defines a particular teaching program" (cf. Landa, 1969, p. 233). "One interesting implication . . . is that it is necessary to use a different program for each student entry when only one outcome is accepted for all students" (p. 235; cf. aptitude-treatment interaction in Cronbach & Snow, 1969).

Experimental studies involving SOCRATES might investigate the effects of alternative programs (treatments) on students with different entry behavior (aptitudes). Such an approach, then, would examine the effectiveness of certain decision rules in matching treatments to individual differences in students in order to optimize learning. Stolurow (1965) reviews some studies using teaching machines (broadly defined) with alternative "programs" that investigated the interaction of aptitude with treatment (see Cronbach & Snow, 1969; Berliner & Cohen, 1972; or Bracht, 1970, for more comprehensive reviews).

A second type of study is exemplified by Nuthall's (1968) extension of work by Smith et al. (1962, 1966). Smith et al. (1966) defined a venture as a single identifiable unit of subject matter; eight different types of ventures were identified. Nuthall chose to study the conceptual venture: "A section of discourse in which the meaning, use, implications of a class term are described or discussed" (p. 562). For any type of venture, a particular unit of information was referred to as a move. Nuthall defined teaching strategy as "the ordered set of conceptual moves which occurred in the venture" (p. 563). Different strategies, then, may be viewed as the result of differences in choices among teaching skills. He identified four logical teaching strategies

and developed programmed texts to simulate each type of strategy. In this way, students could be assigned at random to teaching strategies. Teaching strategies were identical within each of the four major types but differed in specifiable ways between strategies. Nuthall concluded that "differences in teaching strategy could be meaningfully related to differences in student learning. But the generalizability of the results is limited by the lack of a system of classifying meaningful concepts in some pedagogically significant way" (p. 583).

Conclusion and Implications

Any teaching act is the result of a decision, whether conscious or unconscious, that the teacher makes after the complex cognitive processing of available information. This reasoning led to the hypothesis that the basic teaching skill is decision making.

This conceptualization incorporates previous research on teaching skills. Such skills as questioning, explaining, reinforcing, and probing represent the teacher's repertoire of alternative acts from which he must choose at any instant in time. Such skills as listening and hypothesis generation influence the teacher to infer (a) the probability that the student, let us say, does or does not understand the concept the teacher is presenting, and (b) the relative utility of each of the alternative teaching acts.

One implication of this conceptualization is that research on teaching should examine teachers' decisions. Decisions may be the principal focus of research, or they may be studied indirectly when the main concern is the exercise of skilled performance. Another im-

plication is that teachers' training should include a decision-making component. The teacher should be taught not only _how_ to ask, say, higher-order questions, but also _how to decide when_ to ask a higher-order question.

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